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The impacts unnatural foods have on hibernation and health in American Black Bears

Towns, Jakub

THE IMPACTS UNNATURAL FOODS HAVE ON HIBERNATION & IN AMERICAN BLACK BEARS


Source: Bear Centre, n.d.


Source: Wheeler, n.d.


Source: Wild Neighborhoods n.d.

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THE IMPACTS UNNATURAL FOODS HAVE ON HIBERNATION & HEALTH IN AMERICAN BLACK BEARS

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ABSTRACT

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Key Words: Black Bear, cellular aging, hibernation, human food, telomere,

As humans encroach more and more into wild spaces, we will continue to see an increase in the negative impacts our lives have on those of the animals we share these spaces with. One of these ways is through our food. In humans, this food is safe, but in wildlife there are many harmful affects, whether it be through biological and health problems or behavioural changes. Specific impacts on wildlife can include a lack of proper nutrition, toxic materials in the food making them sick, increase the spread of disease if large groups are attracted to the same food source and injuring each other during competitive fights over the food source. One of the most well-known species attracted to man-made food sources is the American Black Bear (*Ursus americanus*.) This thesis will investigate the impacts of consuming unnatural food will have on the health of wild black bears, more specifically on their hibernation patterns and ultimately on the aging of their cells. Studies conducted on this topic have analyzed the length of telomeres, the structure that manages aging in cells, collected from adult female bears at different times of the year. These tests determined that when bears consume large quantities of unnatural food sources, the amount time spent hibernating decreases. Additionally, researchers have found links between a decrease in hibernation time and an increase in cellular aging as the telomeres begin to waste away quicker when hibernation is reduced. In conclusion, this research and others like it could help make people more aware of the harm providing wildlife with access to human food can be and assist in the development of methods to help mitigate these issues.

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ACKNOWLEDGEMENTS

I would like to thank Dr. Mathew Leitch for his help in supervising the creation of this undergraduate thesis, as well as my second reader for taking an additional look at this project.

1.0 INTRODUCTION & OBJECTIVE

As humans encroach further and further into wild spaces, the influence we have on the everyday lives of the species living there will increase. One of these major influences is our food, which can act as an easy meal for hungry wildlife from a variety of species. Although our food is safe for humans to consume, unnatural foods can have a wide variety of harmful effects on wildlife. This can be through not receiving the proper nutritional benefits that their natural food sources would give them and properties in the food being toxic to animals and making them ill, to spreading disease when numerous individuals from different species crowd together and conflict between these individuals that can end in injury or even death (Kirby et al., 2019).

The American Black Bear (*Ursus americanus*; Pallas, 1780) is one of the many species that are attracted to unnatural food sources that were unintentionally provided by humans. According to the Ontario Ministry of Natural Resources and Forestry, black bears primarily focus on foods that provide high energy gains in order to help them build up fat stores for the winter (Ontario, 2020). As a result, these animals are attracted to a wide variety of different foods, such as doughnuts, bird seeds & other feeds, barbequed meat and many more. Unfortunately, according to Kirby et al. (2019), the effects of unnatural food sources on the health, reproductive fitness and other biological processes in bears and other wildlife

species is not a well-understood problem (Kirby et al, 2019).

1.1. Objective:

The purpose of this thesis is to determine if there is a negative connection between the consumption of unnatural food sources by black bears and the health and hibernation of these animals. More specifically, this thesis will attempt to better inform how consuming human foods have a profound negative effect on black bear hibernation patterns and ultimately their health, focusing primarily on their cellular aging and gut microbiomes. Information regarding how and why black bears have come to forage more frequently in human environments and on human food will be discussed, as well as the importance of hibernation in the life of mammals such as black bears. The structures responsible for cellular aging in black bears, telomeres, will also be discussed, specifically on how they can be damaged or negatively impacted and what implications this issue has for black bear health. This thesis will conclude with investigating the potential strategies to mitigate the problem of black bears, and other wildlife species, consuming human food sources in order to reduce the amount of conflict between humans and animals.

1.2. Hypothesis

When bears begin to consume larger quantities of unnatural foods, instead of focusing on the food sources they forage on naturally, this change in behaviour will result in result in a shortening of hibernation periods and changes in their patterns, an increase in cellular aging and a loss of microbiota in their digestive tracts.

2.0 METHODS & MATERIALS

2.1. Sites used to collect information

Information presented in this thesis was collected primarily from peer-reviewed journal articles, supplemented with information from reputable websites like government sites and research organizations. Research sources were found using Google Scholar after finding the titles for these documents through the literature cited pages

3.0 LITERATURE REVIEW

3.1. Unnatural Food Sources

3.1.1. Natural Food Sources

Before analyzing the use of unnatural foods by black bears, it is important to understand their foraging ecology and behaviours. The American Black Bear, although a member of the order Carnivora, is highly omnivorous and opportunistic, taking advantage of a wide variety of different food items. Understanding the food sources black bears would rely on typically in their natural habitats not only assists biologists and other researchers to learn more about the ecology of these animals, but it can also shed light on why bears utilize human spaces and human food in the first place (e.g. is a certain food source in the particular area suffering and/or scarce, causing the bears to seek out new feeding grounds).

When coming out of hibernation in spring to the autumn months, black bears rely heavily on green vegetation as a source of food (Ditmer et al, 2016; North American Bear Center, n.d.). In April, when the bears begin to emerge from their winter dens, they rely on the flowering parts of a variety of deciduous tree species, including aspens, maples, willows and ashes (North American Bear Center, n.d.). As they move into May, the bears will change their focus to grasses and leaves, especially within the first 2 to 3 weeks of their growth, allowing for highly nutritious foods due to the nutrients being in a more fluid-like state that is more digestible (North American Bear Center, n.d.). However, these foods become less important later in the year as the nutrients begin to solidify and form cellulose (North American Bear Center, n.d.). Among the vegetation consumed by black bears during this time of the year include grasses like the Canada bluejoint (*Calamagrostis canadensis*; P. Beauv), leaves of the aspens and asters, fern stems, skunk cabbage, clover and wild calla (*Calla palustris*; Linnaeus) (North American Bear Center, n.d.). In the summer, due to the cellulose, bears change focus from green vegetation to other food source but they will still feed on some, especially when more desirable food sources are scarce or unavailable entirely. These can include the legumes, jewelweed (*Impatiens capensis*; Meerb) and wild lettuce (*Lactuca canadensis*; Linnaeus), as well as sometimes consuming the roots of water parsnip (*Sium* suave; Walter) and cattails (Typhaceae; Juss) (North American Bear Center, n.d.).

Throughout North America, berries are an important food source for black bears, especially during the summer months with the decline in the nutrients of green vegetation (North American Bear Center, n.d.). This species will consume a wide variety of different berry species, including blueberries, sarsaparilla berries, cranberries, strawberries, juneberries, dogwood berries, blackberries, serviceberries, and wild raspberries (Beeman & Pelton, 1980; Kurta, 1995; North American Bear Center, n.d.). Despite the diversity of species bears feed on, there are still some that they will avoid such as blue lily berries, baneberries and elderberries (North American Bear Center, n.d.). Not only are berries an important food source for giving the adequate nutrients to these large omnivores (a large bear can eat as many as 30,000 berries in a season) they also assist with keeping the bears healthy (North American Bear Center, n.d.). Since many berries have anti-oxidants in them, as well as seeds containing the nutrient known as B-17, bears whose diets consist largely of berries are highly tolerant to cancer and other cell issues (North American Bear Center, n.d.). In fact, no wild bear has been recorded with a case of cancer that has been seen in captive bears. Black bears are also important seed dispersers for some tree and shrub species, as the seeds within the berries germinate after passing through the digestive system of a bear allowing the seeds to grow in new areas. There are even some species, such as the Canada plum (*Prunus nigra*; Aiton), whose berries can only be dispersed by animals the size of a black bear (North American Bear Center, n.d.). Other forms of fruit that are consumed by black

bears include apples, grapes and cherries (Kurta, 1995).

Just like berries, hard mast is another important food source for bears during the summer months, so much so that the availability of nuts and acorns can determine how well bears will grow and the number of offspring they will produce (North American Bear Center, n.d.). Bears will gorge themselves on a variety of different hard mast, including but not limited to acorns, hickorynuts, hazelnuts and beech nuts. Black bears are highly dependent on the availability of hard mast as this food source has an influence on a variety of different aspects in the life and survival of bears. In many areas, when acorns and other forms of nuts aren't found in huge numbers, it can take longer for female bears to be able to have cubs; they can be 6.3 years of age before being able to give birth while bears in areas with a large quantity of hard mass can have cubs at half this age (North American Bear Center, n.d.). In addition, a plentiful hard mast resource can result in a boost in weight for hibernation, cubs will be born stronger and healthier and can even cause a decline in the number of bear-human conflicts.

Although they consume a large quantity of plant matter, the American Black Bear still has the anatomy of a carnivore, hence why they have been placed in the mammalian order *Carnivora*. However, it isn't a major component of their overall diet, with approximately 10% depending of the food they consume consists of animal protein (North American Bear Center, n.d.). The majority of this protein comes from insects including ants and their larvae, bees and their larvae, grubs and even forest tent caterpillars. Other invertebrates consumed include snails, crayfish

and centipedes (Beeman & Pelton, 1980).When feeding on vertebrates, black bears will take the opportunity, should one present itself, to take eggs and young chicks out of bird nests, snakes, frogs, toads, salamanders, fish, small mammals and young ungulates like deer fawns which provide an easy form of protein in the earlier parts of the spring when the new fawns are being born, although it isn't very common (Kurta, 1995; Ditmer et al, 2016; North American Bear Center, n.d.). Carrion is also another source of protein for black bears (Kurta, 1995).

3.1.2. Use of Urban Landscapes

When animals begin looking for food, it is vitally important that they weigh the pros and cons of a potential feeding area. There are always trade-offs these organisms must consider if they are to survive. With the further encroachment of human development, the number of pros and cons of foraging areas begins to increase and, as a result, the trade-offs begin to change (Merkle et al. 2013). For example, an animal that begins foraging in more human-dominated landscapes will find an environment that has plentiful food sources, but at the same time they are more likely to encounter a threat (humans, vehicles, pets, etc.) (Merkle et al. 2013). As a result, animals have begun to try and adapt to these changes, such as only foraging at night when there are fewer people active or go as far as to stick to the remaining natural habitat and avoid entering a city or small town (Merkle,

et al. 2013; Baruch-Mordo et al. 2014). The American Black Bear, being a highly opportunistic forager, are known to frequently use urban areas despite the long list of potential threats they could face, such as lethal control and vehicle collisions. However, bears typically only use urban environments for a short period of time, entering these landscapes to forage then exit to follow the changing of seasons and what foods will be available at that particular time of the year (Merkle et al. 2013).

According to a study conducted by Merkle et al. (2013) there are two primary reasons why bears will utilize human-dominated landscapes as a potential foraging area: firstly, the natural food sources they rely on in their regular habitats are scarce, as seen in a study on Grizzly Bears (*Ursus arctos horribilis*) in Yellowstone National Park where there was a spike in activity where bears were raiding campsites and other areas frequented by people (which also created a spike in the number of human-bear conflicts in these specific years) when the natural production of their typical food sources was low, and secondly, foods that we eat are generally very attractive to black bears (Merkle et al. 2013). Food scraps thrown in the garbage can provide scavenging bears with an abundant source of easy food.

It has been observed that the plentiful food sources found within urban landscapes can cause a decline in black bear population densities in their natural habitats. One such example in the Sierra Nevada Range and Great Basin Desert regions found population densities in natural environments rapidly declining from approximately 20 to 40 bears per 100 km^2 a decade prior to only 3.2 bears per

100 km², indicating that some bears are finding foraging in an urban setting to be more efficient and plentiful than those found in their natural habitats. (Beckmann & Berger, 2006).

3.1.3. Resources Attracting Black Bears

Black Bears are attracted to urban areas due to the need of finding food. They are highly opportunistic and are quick to take advantage of available food sources. According to the Ontario Ministry of Natural Resources, the primary attractants to black bears that can coax them into entering urban landscapes include the scent of foods, whether it be cooking on a grill for example or food sitting in a cooler or on a table outside (Ontario Government, 2020). As long as the attractants are present, and bears know they can easily get at the food, they will continuously return to these sites to feed. Due to this behaviour, understanding what specific attractants will potentially bring bears into an area they are not supposed to be in is important in order to make sure the animals are consuming their natural food sources instead and pose no threat to the health and safety of themselves and the public. The physical attractants that often bring bears into urban landscapes include garbage, unclean barbeque grills, bird feeders, fruiting trees in a backyard that are ripe or have fallen fruits at the base and pet food left outside and unattended (Ontario Government, 2020).

3.2. Hibernation

3.2.1. Biology/Chronology of Black Bear Hibernation

Hibernation is defined as a reduction in metabolism that happens seasonally and usually coincides with food scarcity and colder temperatures (Watts et al. 1981). Hibernation is an important aspect of a black bear's lifecycle. The purpose of hibernating each year is to conserve energy when there is a shortage of available food (not utilizing energy stores looking for the little food that may not be present at that time of the year), as well as reducing the metabolism so a limited amount of energy is used to run the body when food will be difficult to find. However, black bears are not true hibernators or deep hibernators like bats and the Woodchuck (*Marmota monax*), and will show periods of activity interlaced with periods of sleep, with the most amount of sleeping happening during the middle of the hibernation period (Nelson et al. 1983; Kurta, 1995; North American Bear Center, n.d.). Other terms that can be used to describe a black bear's 'hibernating' behaviour can include torpor, dormancy and carnivorean lethargy, although many physiologists and other professionals will still refer to this behaviour as hibernation (Kurta, 1995; North American Bear Center, n.d.).

Each year, black bears go through five phases that make up the hibernation process: 1) hibernation, 2) walking hibernation, 3) normal activity, 4) hyperphagia and 5) fall transition (North American Bear Center, n.d.). The specific time when black bears enter their dens for hibernation varies with their location in North America. When hibernating the metabolic rate begins to decrease including the heart rate, body temperature and oxygen consumption, as well as a reduction in

blood flow to skeletal muscles like those in the legs and an overall decrease in the animal's bodyweight. When in hibernation, relying on their fat reserves for energy, a black bear can lose as much as 4,000 calories per day and by the beginning of spring bears could lose 20% of their total weight (Nelson et al. 1983; National Park Service, n.d.). In addition to not eating and relying on their fat reserves, hibernating bears will not drink or pass waste (Nathan et al. 1983). The body temperature of a hibernating black bear will decrease but not as much as other animals that hibernate like chipmunks, who lower their body temperatures to a mere 4˚C (40˚F) (North American Bear Center, n.d.). Black bears will lower their internal body temperatures to between 35 and 31˚C (95 and 88˚F), a three to seven degree drop from their typical walking temperature (Nelson et al. 1983; Kurta, 1995; National Park Service, n.d.). This very slight change in body temperature is what allows black bears to awaken easily from sleep should they feel threatened and need to escape or defend themselves, as well as only needing their fat reserves to survive due to not having to constantly feed to keep heat their bodies (Kurta, 1995.) However, females who have given birth to cubs will maintain a body temperature that is close to their regular temperature due to having to look after their offspring. During the act of hibernation, the heart rate will decrease to between 8 and 21 beats per minute (Kurta, 1995; North American Bear Center, n.d.). In addition, the consumption of oxygen will decrease by as much as 25% as the consumption would be if the bear was active. This means a hibernating black bear will take one breath every 15-45 seconds (North American Bear Center, n.d.).

The next stage in the process is known as walking hibernation, which happens soon after the bears emerge from their dens in spring (North American Bear Center, n.d.). During this time the bears become anorectic, with rate of food and water consumption by the bears is still greatly reduced (Nelson et al. 1983). In addition, the amount of waste they pass due to their bodies still recovering from the metabolic changes that occurred during the winter (North American Bear Center, n.d.). Walking hibernation typically lasts around 2 weeks; studies conducted on captive black bears who have just emerged from hibernation found that the bears didn't feed for 10-14 days after emerging (Nelson et al. 1983). After they go through walking hibernation and their bodies have returned to normal, black bears will enter a stage known as normal activity. This typically coincides with the arrival of green vegetation in the spring and will typically last until midsummer but may last until September depending on the region the bear is found in (Nelson et al. 1983; North American Bear Center, n.d.). During this critical stage in the hibernation process, bears must have a plentiful food source and reliable source of water or they can suffer from damaging and potentially lethal consequences. These health issues include dehydration which could lead to nitrogenous waste building up in the blood as well as the use of the muscles for energy. During this stage, a black bear can consume anywhere between 5,000 and 8,000 kcal per day (Nelson et al. 1983; North American Bear Center, n.d.).

After the normal activity phase, black bears will enter a hyperphagia stage where their food consumption increases dramatically to where they can consume 15,000 to 20,000 kcal per day (Nelson et al. 1983; North American Bear Center, n.d.). Bears will

also drink excessively during this time as a way to help process the large amounts of food they're consuming at this time, as well as remove waste. During the hyperphagia stage, black bears can spend up to 20 hours per day foraging and drinking (Nelson et al. 1983).

The final stage of the hibernation process is known as the fall transition. During this stage, the metabolism of a black bear begins to revert back to what it was during the actual hibernation stage. The bears begin to eat less and become more lethargic, although they do drink excessively to help clear their bodies of any remaining waste. Their heart rates will begin to decrease during this stage as well; during the fall transition period, their active heart rate will drop from the typical 80 to 100 beats per minute to 50 to 60 beats per minute (North American Bear Center, n.d.). In addition, the sleeping heart rate will dramatically decrease from 66 to 80 beats per minute to less than 22 beats per minute (North American Bear Center, n.d.). Hibernation for black bears can last anywhere between 3 and 7 months (Nelson et al. 1983).

The definition of a den is the location where a bear chooses to spend the winter months while hibernating (North American Bear Center, n.d.). Dens are extremely important to bears during their hibernation period because they provide them a place to conserve energy when the availability of food declines during winter, protection from disturbances and, more importantly for female bears, a safe place in which to give birth and begin raising their cubs (Waller et al. 2012). When determining the right time of

year to enter their dens, black bears will use multiple different factors to determine the right time to enter hibernation. These include a reduced photoperiod and temperature during late autumn and early winter is an important indicator for the species as a whole with the energy balance during this time of the year being an important indicator for individuals (Baldwin & Bender, 2010). When it becomes time for black bears to enter their dens, the energy balance becomes negative and, as a result, foraging will burn more energy than the bears can consume to replenish the energy used. This means that there is no advantage to foraging on any food that is left during this time of the year. Even the types of food available in a bear's habitat can help researchers estimate when they will enter their dens for the winter (Baldwin & Bander, 2010). One of the ways this can be done is through a remote-sensing technique known as the Normalized Difference Vegetation Index (NDVI) (Baldwin & Bander, 2010). This technique measures the greenness of vegetation in an area and correlates with the primary productivity of the vegetation. This method has been used extensively with Grizzly Bears (*Ursus arctos horribilis*), specifically habitat selection by the bears (Baldwin & Bander, 2010). As a result, NDVI may be a useful tool in determining den chronology in the American Black Bear. Unfortunately, there are some problems that have been highlighted with using the NDVI for black bear den chronology with the primary issue being it is unable to discern any other food sources besides green vegetation (Bander & Baldwin, 2010). Potential food source like berries, insects and even human food will not show up on the index.

Human food specifically has become a potential issue when determining the natural den chronology of black bears. Due to the lack of abundant food in early spring, black bears will utilize any easy food source they can while going through their normal activity phase. The year-round availability of human food can result in bears emerging from their dens and begin foraging earlier and entering their dens later than usual (Bander & Baldwin, 2010).

The region in which black bears inhabit is the deciding factor on when they will begin to enter and emerge from their dens with more specific factors indicating the start/end of hibernation include air temperature, the sex and age class of the bears (Bander & Baldwin, 2010). For example, a study conducted on black bears in Mississippi found that, on average, males would typically enter their dens later than females, who would typically emerge from their dens at a later date than male bears (Waller et al. 2012). When male bears entered their dens for hibernation, the range was around December 26th to February 28th, with the median being January 17th (Waller et al. 2012). For females, they generally went into hibernation anywhere between November 16th and January 21st, with the median being December 3rd (Waller et al. 2012). When emerging from their dens, the males will typically emerge between March 4th and March 28th, the average date being March 12th (Waller et al. 2012). Female bears will typically emerge from January 26th to April 13th, with the average being March 18th (Waller et al. 2012). In addition, it appears that this data on Mississippi black bears is similar to observations made for black bears found throughout the southern United States. In comparison, male black

bears in Alaska have been observed entering their dens typically around October 4th whereas females would begin hibernating as early as September 30th (Smith et al, 1994.). At the end of hibernation, males would emerge, on average, around April 15th whereas females emerged around April 23rd (Smith et al. 1994). There is some slight difference in the approximate dates when bears from different locations in North America enter and exit hibernation but it shows that the chronology can vary depending on where the bears are found.

3.2.2. Link Between Hibernation & Lifespan in Mammals

Hibernation is a process that has only been observed in eight groups of mammals, the Carnivora (the group that the American Black Bear belongs to), as well as bats, rodents and even some primates (Wu & Storey, 2016). Mammals that go into hibernation can slow their metabolism down so they use up as little energy as possible through running bodily functions (normal heart rate, breathing rate, etc.). This process can directly impact the longevity of hibernating mammals as the metabolism, in combination with the body size, determines just how long an animal will live (Wu & Storey, 2016). The metabolic rate of a mammal shows a positive relationship with the body size of the animal, but a negative relationship with lifespan; in short, mammals with a larger body size tend to have a slower metabolism then smaller mammals and therefore usually have longer lifespans (Wu & Storey, 2016). However, there are many exceptions to this rule. Many mammals with smaller body sizes can live longer as a result of slowing their metabolism down during hibernation and similar behaviours

when the conditions in their habitat become unfavourable. For example, according to Wu & Storey, bats such as the Little Brown Bat (*Myotis lucifugus*) hibernates each year and can live to be anywhere between 34 and 41 years, approximately 9.8 times the length of time an animal of this species' size should live according to their metabolic rate and body size (Table 1) (Wu & Storey, 2016).

3.2.3. Impacts of Unnatural Foods on Hibernation

Hibernation is an important component in the life cycle of black bears. However, the consumption of unnatural food sources can result in problems with hibernation, particularly with the amount of time they actually spend hibernating. When human food is available year-round, it has been observed that black bears will continue feeding for longer periods of time than what they normally would during the year, resulting in their denning up at a later date, therefore shortening the hibernation season (Kirby et al. 2019).

When female black bears in one such study were sampled for the isotope δ13C, which is a carbon isotope used to determine the proportion of an animal's diet that different foods make up, to determine if the amount of unnatural food they consumed over the summer months resulted in changes to their hibernation length (Ditmer et al, 2006; Kirby et al. 2019). The results of the study found that the more unnatural foods the bears consumed, the shorter their hibernation period was (Figure 1) (Kirby et al. 2019).

Table 1. Lifespan of small mammals that hibernate and lower their metabolic rates compared to mice and rats. Source: Wu & Storey, 2016.

Species	Common Name	Lifespan (yrs)	Body Mass (g)
Myotis lucifugus	Little Brown Bat	34	5.8
Heterocephalus glaber	Naked Mole Rat	31	35
Marmota flaviventris	Yellow-bellied Marmot	21.2	4295
Echinops telfairi	Lesser Hedgehog Tenrec	19	180
Microcebus murinus	Gray Mouse Lemur	18.2	64.8
Icidomys tridecemlineatus	13-Lined Ground Squirrel	7.9	198.4
Mus musculus	House Mouse	4	20.5
Rattus norvegicus	Norway Rat	3.8	300

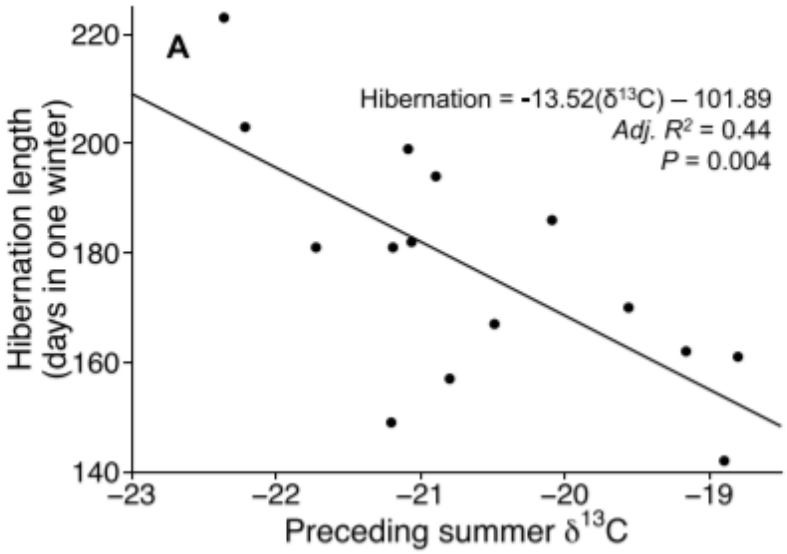

Figure 1. Relationship between shorter hibernation periods and an increase in unnatural foods consumed Source: Kirby et al. 2019.

One study observed the impacts of the utilization of urban landscapes as foraging areas found that out of 38 bears studied, 5 bears (or 13% of the study set) did not den up for the winter and therefore didn't hibernate (Beckmann & Berger, 2006). Those individuals

who did create a den and went into hibernation for the winter entered their dens later than bears who fed upon natural sources of food and emerged earlier (Beckmann & Berger, 2006).

3.3. Telomeres & Cellular Aging

3.3.1. Description of Telomeres

Telomeres are sequences of DNA that repeat themselves found on the tips of linear chromosomes in eukaryotic organisms (Kirby et al. 2019; MBINFO, n.d.). These structures, which protect the genetic information of the organism, begin to deteriorate when cells begin to replicate themselves, as well as when oxidation stress or damage is caused (Kirby et al. 2019). Telomeres are considered to be markers for cellular aging (Kirby et al. 2019).

The length of telomeres is not set for all species and is highly variable between individuals (Kirby et al. 2017). Factors that can influence the length of the telomeres in an organism include age, sex, body size and even the environment the individual inhabits. Older animals tend to have shorter telomeres than younger individuals, with female specimens having longer telomeres than males (Kirby et al, 2017.). In addition, the larger the body size of an individual is the shorter their telomere length will be. Telomere lengths can be heritable and passed down to an individual's offspring although this varies between species (Kirby et al. 2017).

Recent studies have found that environmental factors play an important role

in determining the length of an individual's telomeres, mostly through habitat quality and the type of food they can obtain (Kirby et al. 2017). When the habitat and available food is not the best quality, this can cause the animal's body to become stressed. As a result, the oxidative stress will begin to increase and cause the telomeres to deteriorate at a faster rate (Kirby et al. 2017).

3.3.2. Impacts of Unnatural Foods on Cellular Aging

The impact unnatural food sources have on the cellular aging of black bears is indirect (Kirby et al, 2019). Any negative impacts on cellular aging are primarily a result of issues that arise through hibernation. Based on a study conducted by Kirby et al. (2019) where approximately 30 female bears were sampled in order to observe the length of their telomeres to determine their how long they were hibernating, along with using the carbon isotope δ13C, to figure out the unnatural food sources the bears consumed, it was found that bears that consumed large amounts of unnatural foods hibernated for shorter periods of time than bears that consumed little to no human food (Kirby et al. 2019). The bears that hibernated for a shorter period of time displayed telomeres that degraded at a faster rate than those from bears that hibernated for a usual period of time (Kirby et al. 2019). Due to the length of the telomeres reducing more rapidly than they would under normal situations (i.e., natural diet, typical hibernation period) the process of cellular aging will rapidly increase and, as a result, cells will begin to die faster. Unfortunately, this process still is not well understood, and more research is needed.

3.4. Digestion & Gut Microbiota

3.4.1. The Gut Microbiome of a Black Bear

A gut microbiome is a collection of microbial communities that can be found residing within the gastrointestinal tract of an animal consisting of a wide variety of species of microbes that benefit from one another (Gillman, 2020). The purpose of this microbiome is to assist in making sure the animal's physiology is functioning properly and serves a variety of functions including maintaining the animal's immune system, developing tissues, the synthesizing of vitamins, proper digestion and regulating the individual's weight (Gillman, 2020). Most microbial communities are found in the rear sections of the gut. A variety of factors can determine the composition of the microbiome. Habitat quality and diet, in addition to the availability of the food source, can determine what the microbiome of a black bear will be composed of. Other factors include the sex of the bear, it's age and its phylogeny (Gillman, 2020). A diverse microbiome can help increase the plasticity of not only bears but other organisms. This allows them to better adapt to changing environments, especially those disturbed through human-derived threats (Gillman, 2020).

There are at least four major groups of microbes making up the microbiota of an American Black Bear: *Firmicutes, Proteobacteria, Actinobacteria* and *Epsilonbacteraeota* (Gillman, 2020). The colon and the jejunum, the mid section of the small intestine, have collections of microbiotas that are shared between the two locations, but there are also unique microbes to each structure (Gillman, 2020). Of the

four major taxa, *Firmicutes* and *Proteobacteria* were found in both the colon and jejunum, while the *Actinobacteria* and *Epsilonbacteraeota* were found only in the jejunum and colon, respectively (Gillman, 2020). The *Firmicutes* was found to be the most dominant phylum of microbiota found inside the bear's digestive tract, making up around 70% of the microbiome composition in the jejunum and 60% in the colon (Gillman, 2020). The *Proteobacteria* aren't as common, making up about 24% of the community in the jejunum and 33% in the colon (Gillman, 2020). The *Actinobacteria* and *Epsilonbacteraeota* make up very little of the communities they're part of, only making up 1.6% and 5.4% respectively (Gillman, 2020). The study conducted by Gillman also found a number of more minor taxa present in each microbiome, but they made up less than 1% of the communities (Gillman, 2020).

The gut microbiome can be altered by consuming unnatural food sources (Gillman, 2020). This is especially true for captive black bears, and this can cause problems with research as the microbiome of a captive individual can be substantially different than the microbiome found in the body of a wild specimen, ultimately not providing accurate data on how unnatural foods impact the wild population (Gillman, 2020). When data is taken from bears, both captive and wild specimens, samples are primarily taken from the feces (Gillman, 2020). This means the majority of information on the microbiome of black bears comes from the colon. However, the most useful data comes from the jejunum, the middle of the small intestine, where 90% of the fats, carbohydrates and proteins consumed by the bears are absorbed (Gillman, 2020). Researchers focus on samples from the colon of a black

bear instead of the jejunum because any samples that could be extracted from the small intestine would be too invasive, leading to a lack of knowledge on the diversity of a black bear's microbiome (Gillman, 2020).

3.4.2. How Human Food Impacts the Gut Microbiome

The diversity of microbes found inhabiting the digestive tract of not only black bears, but other organisms, is vitally important for the proper function of the body and its processes (Gillman, 2020). There are many functions within the body that require multiple species of microbes within the gut in order to work properly. However, there are others that require a specific species of microbe and should this species be removed from the microbiome due to exposure to human food then the process or function will not work properly or will cease to work entirely (Gillman, 2020).

3.5. Mitigating the use of Unnatural Foods

3.5.1. Aversive Conditioning

Black bears will continue to feed on unnatural foods due to becoming habituated to humans and this resource. Habituation, according to Mazur (2010), is defined as an animal losing behaviours focused on avoidance as a result of extensive periods of time where they experience positive stimuli and little to no negative stimulus. When bears become habituated to humans and their food, they

are often dealt with using lethal control as it is considered more convenient and efficient than trying to manage the bears and keep them alive (Mazur, 2010). However, in recent years lethal control has faced many obstacles, including protests conducted by animal rights activists and some black bear populations are at risk, such as the Louisiana Black Bear subspecies (*Ursus americanus luteolus*) which is considered threatened by the US Fish & Wildlife Service (US Fish & Wildlife Service, 2019).When bear populations are threatened, it is illegal to use lethal control to manage nuisance animals as important breeding individuals could be removed from the population, resulting in the population decreasing further. As a result, new forms of bear control and management need to be implemented to not only prevent bears from consuming unnatural foods and relying on human-dominated landscapes but also keeping the public safe.

Aversive conditioning is potentially one of these solutions. An operant conditioning technique (a reward or punishment is presented to change behaviour) aversive conditioning is when pain, fear and other forms of discomfort are used to alter an animal's behaviour (Mazur, 2010). The goal behind aversive conditioning is to permanently stop bears from consuming unnatural foods; avoid humans and their residences and have them focus on their natural food sources. However, this technique does have drawbacks as many bears that have been exposed to the tools used in aversive conditioning may eventually resort to unnatural foods (Mazur, 2010). Unfortunately, information on how successful aversive conditioning methods is limited due to a lack of research done on the subject (Leigh & Chamberlain, 2008).

There are a wide variety of techniques that can be classified under aversive conditioning (Mazur, 2010). The best technique, as stated by Mazur, is one that makes the bears realize that when they approach humans and eventually start consuming their food they will experience something negative in the hope that the animal will cease the behaviour (Mazur, 2010). Some of the most popular aversive conditioning techniques include the use of rubber or plastic shotgun slugs (Mazur, 2010). The purpose of these projectiles is to cause a stinging pain when making contact with the bear's skin to deter them from entering the area again and eating any unnatural foods in the vicinity. Other types of projectiles used to deter food-habituated bears include slingshots with rocks (Mazur, 2010). Pepper spray is another popular deterrent to assist with altering bear behaviour due to how successful this projectile appears to be in stopping potential bear attacks. Unfortunately, from observations where these tactics were used on both American Black Bears and Polar Bears (*Ursus maritimus*), the bears that are exposed to these projectiles will leave the specified area temporarily and there is a high likelihood they will return (Mazur, 2010). Black bears in Sequoia National Park, for example, were exposed to these projectiles in order to determine the short-term and long-term success of rubber shotgun slugs, lower impact projectiles and pepper spray (Mazur, 2010). Between all the projectile deterrents used, rubber slugs were the most effective with both bears that had no exposure to human food and those that were food conditioned run immediately after experiencing the negative stimulus, with fewer than half of the bears in the two categories either slowly leaving/climbing a tree or staying in

place/approaching humans and food (Figure 2) (Mazur, 2010). Chasing non-conditioned bears was more successful than chasing bears that were food-conditioned as 70% of them immediately ran instead of slowly leaving, climbing a tree or staying put (Mazur, 2010). Slingshots with rocks and other projectiles appeared to be more effective in making food-conditioned bears run away (48%) than non-conditioned bears (39%) (Mazur, 2010). Pepper spray was almost equally effective in deterring both groups of bears, being more effective against the non-conditioned bears at 39% (Mazur, 2010).

Another area of interest is how long bears would remain distant from urban areas and in turn, human food. The study found that chasing was most effective at making food-conditioned bears avoid human-dominated areas for more than an hour after their exposure to negative stimulus (Figure 3) (Mazur, 2010). Based on the results, chasing and pepper spray appear to be the most successful tactics for driving bears off for more than an hour before they returned, with chasing being more successful on food-conditioned bears (84%) while pepper spray was most successful against non-conditioned bears (77%) (Mazur, 2010). Unfortunately, bears will still return, resulting in the projectile deterrents being more short-term solutions to the issue.

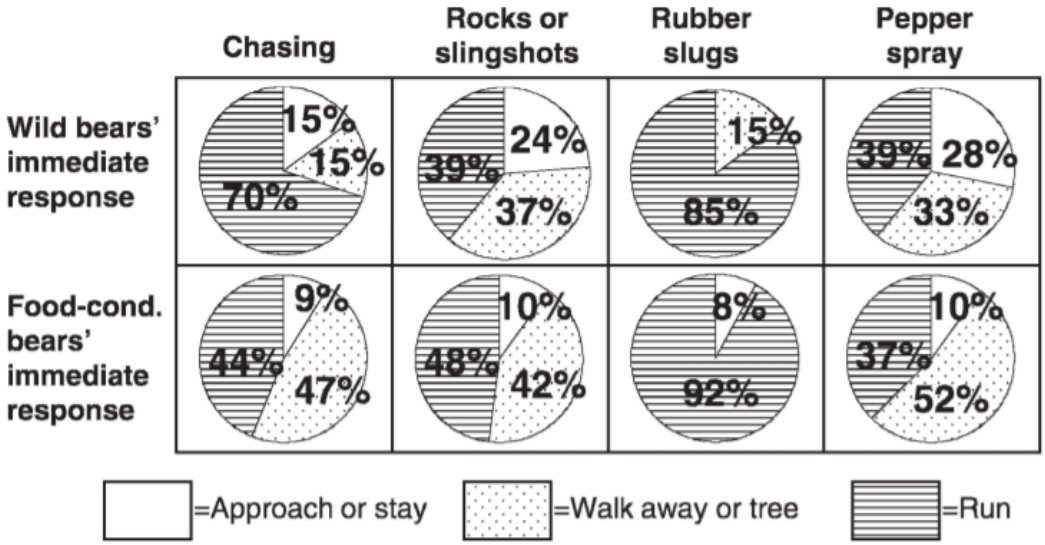

Figure 2. Reactions to negative stimuli via projectiles on wild and food-conditioned bears. Source: Mazur, 2010.

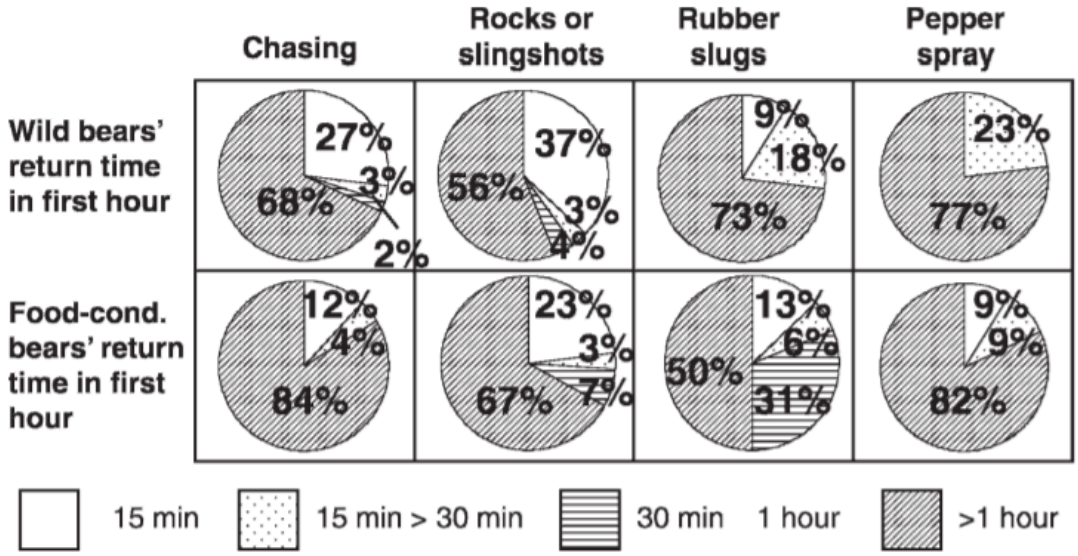

Figure 3. Short-term impacts of negative stimulus on food conditioned and un-conditioned bears. Source: Mazur, 2010.

Trapping is also a common aversive conditioning method where a culvert trap is placed with bait in order to attract bears. When the bears go for the bait, they become trapped and are forced to remain stuck in the trap for extended periods of time. Leaving

the bears confined to a small space for long periods of time is a way to make the bears associate humans and their food with discomfort (Mazur, 2010). In addition, traps are often paired with other forms of aversive conditioning like rubber shotgun slugs, noise making devices such as bear bangers and even chasing with dogs in order to instil a further feeling of discomfort and fear that the bears should associate human-dominated landscapes with. Trapping has been considered and effective tool for causing bears to avoid more urban environments, and in turn human food, but there is evidence that suggests bears that are already food-conditioned may eventually return to where they were trapped and begin feeding on unnatural foods again (Mazur, 2010). In fact, there is a possibility that some bears may begin associating the traps with food as they are sometimes baited with unnatural foods, which could help make the problem more destructive to the health and hibernating habits of the bears. Other cons to setting traps to stop bears from consuming unnatural foods include the cost, both in time and money, as these devices are expensive to buy and set up and may have to sit for extended periods of time (Mazur, 2020). Despite this possible downside, trapping bears does seem to keep non-food-conditioned bears away from people and their foods, but bears that are already conditioned to foods will be more likely to avoid humans, improving the safety for both people and the bears though they could become more difficult to trap when they return (Mazur, 2010).

Taste aversion is another tactic sometimes used to stop bears from consuming human food. This is done using illness-inducing chemicals, which makes the food distasteful to the bears that consume it (Mazur, 2010). Unfortunately, this technique

does not have a high success rate as it typically only causes bears to avoid that particular food the chemical has been coated on and it does not always have a permanent impact (Mazur, 2010). Electricity has been another tool used to help try and solve the issue. Shock collars and electrification have been used to deter bears from human food using pain as a negative stimulus. Electrification, like the chemicals, did deter bears from certain foods but the bears continued to consume other unnatural food sources, not making the connection between human food with this pain (Mazur, 2010). Additionally, shock collars had an immediate effect on both captive and wild bears in preventing them from eating human food. However, once the shock ceased, the bears continued to consume the food, making them a very limited and temporary technique (Mazur, 2020).

Finally, dogs have been used as a deterrent to encourage bears to run and avoid areas they would frequent when foraging on human food. Studies have used dogs to determine how successful the animals are as a bear deterrent, as well as how successful they would be if paired with other deterrents. When working with Louisiana Black Bears, one such study focused on dogs used alongside a combination of culvert traps and rubber slugs. In total, 11 bears were sampled; 5 individuals were treated with only rubber slugs while 6 bears were treated by a combination of rubber slugs and dogs (Leigh & Chamberlain, 2008.). The study found that bears kept a greater distance away from human-dominated landscapes, for a longer period of time, when treated with a combination of rubber slugs and dogs than those that were only exposed to rubber slugs as a deterrent (Figure 4) (Leigh & Chamberlain,

2008). Unfortunately, like many aversive conditioning techniques, the bears were only deterred for a short time frame, with many returning to their nuisance behaviour. It is possible that a combination of different aversive conditioning techniques, as well as multiple treatments, may be the key to keep bears from entering human-dominated landscapes and consuming unnatural food for the long-term instead of only for a short time frame.

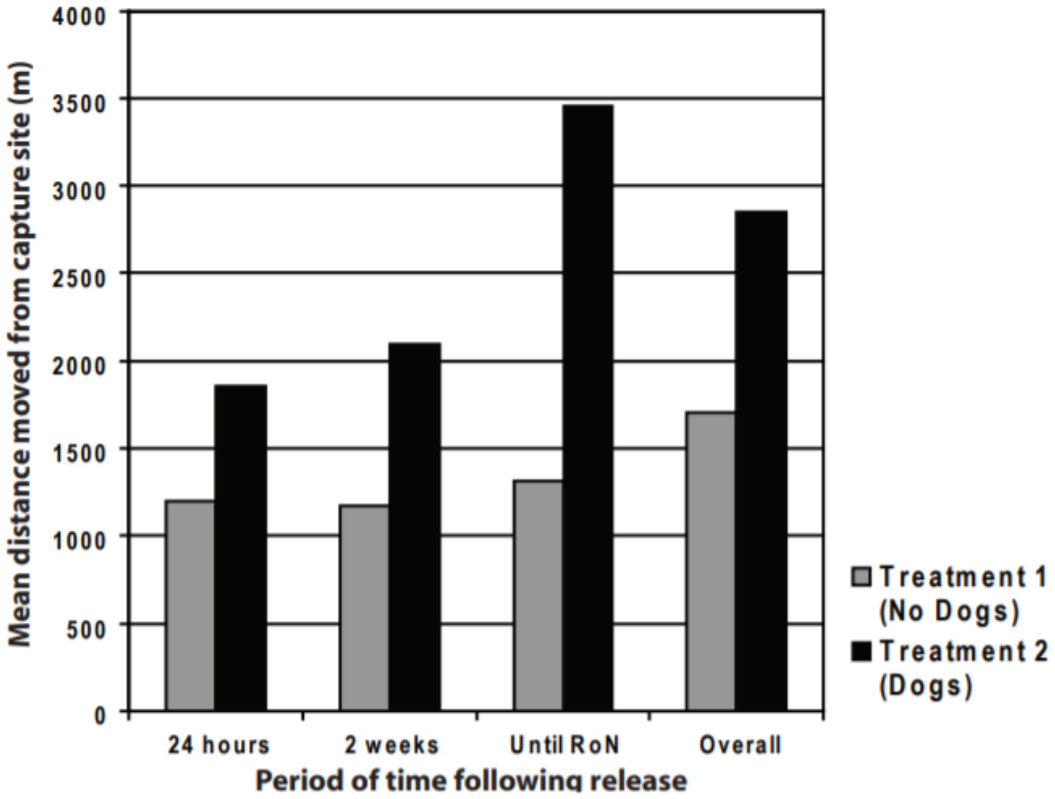

Figure 4. Comparison of distance travelled by bears deterred by dogs. Source: Leigh & Chamberlain, 2008.

3.5.2. Mitigation for the General Public

Preventing black bears from feeding on unnatural foods and/or utilizing human-dominated environments as foraging grounds isn't work that can only be done by professionals. There are many actions the general public can take in order

to help mitigate the negative impacts human foods have on black bears, as well as keeping themselves safe in the process. The American Black Bear can be attracted to human-dominated landscapes by a wide variety of potential food sources, ranging from garbage and barbeques to bird feeders and even leftover pet food (Ontario Government, 2020). Garbage is a well-known bear attractant and it is recommended that garbage is taken out for curb-side pick up the morning waste will be taken away; leaving garbage out overnight increases the chances of a bear having enough time to find it and consume any food scraps found inside. In addition, any bins taken out for garbage collection should have tight-fitting lids to not only make it difficult for bears to open them, but other wildlife as well (Ontario Government, 2020). During the days leading up to garbage collection, bins should be stored in strong structures that make it difficult for bears to enter. These can include sheds, garages and even the basement of a house. Any food scraps, especially meat scraps, should be stored in a freezer and then put with the rest of the garbage the morning of collection (Ontario Government, 2020). After garbage is collected, the bins and lids should be thoroughly washed to remove the scent of any food and other attractive odours left over. When there is no curb-side pickup it is recommended that garbage be taken to a landfill (Ontario Government, 2020).

Bird feeders are attractive to black bears. As a result, bird feeders should only be used during the winter months when bears are in their dens and relying on their fat stories instead of foraging (Ontario Government, 2020). Feeders should be removed in spring and summer, replaced with alternatives that are less likely to attract the attention

of bears such as flowers and water sources for drinking and bathing. When cooking outdoors, such as on a barbeque, it's important to always be aware of what is going on in the general area. After each use, all food residue that is stuck to the grill should be burnt away or scraped off, followed by washing the grill in order to remove the remaining scent (Ontario Government, 2020). In addition, the grease trap should be emptied or the scent of the grease could potentially attract the attention of bears in the area. Extra food, used utensils, plates and cooking equipment should be left outside, especially if covered in food residue. Take them inside a strong structure to be cleaned and stored (Ontario Government, 2020).

Trees and shrubs that produce fruits, although natural food for bears, can cause issues because the scent of fruits and berries can lead bears into human-dominated landscapes, increasing the chances of the animals encountering unnatural food sources and consuming them. When fruit-bearing plants are present in a yard, it's important to remove any ripe and fallen fruits to prevent them attracting bears into neighbourhoods (Ontario Government, 2020). Another way to prevent bears from being attracted to human-dominated landscapes through fruiting trees and shrubs is to simply plant species that reproduced without fruits (Ontario Government, 2020). Pet foods can also act as an attractant to black bears. Pet food shouldn't be left outside unattended or in locations where bears can access the food easily (Ontario Government, 2020).

4.0 CONCLUSION

As humans continue to encroach further into the wild spaces that remain, the availability of unnatural food sources will increase. Due to being highly opportunistic feeders, the American Black Bear will take advantage of these substitutes. Despite the possibility that these foods can provide bears with a reliable food source and provides short-term benefits, these foods will begin to cause damage to the animals in the long-term. Although limited, the research that has been done on the connections between the consumption of human foods and hibernation, cellular aging and gut health appears to show that there is a negative relationship between them. Based on studies conducted on the subject, it has been found that the heavy consumption of unnatural foods can cause a decrease in the amount of time bears hibernate; entering their dens later and emerging earlier due to the year-long availability of human foods (Kirby et al. 2019). As a result of the decline in the amount of hibernation time, the cellular aging markers known as telomeres begin to quicken in their deterioration. (Kirby et al. 2019). Finally, the microbiomes found within the guts of these bears and serves a wide variety of purposes, will begin to lose its diversity when the amount of human food consumed increases, potentially stopping these important functions altogether (Gillman, 2020). In order to better understand the impacts unnatural food sources have on not just black bears but all wildlife and how to properly manage this issue, more research should be conducted into how human foods negatively impact the health and hibernation in bears in order to better understand how the problems originate and how they can be properly managed in the future. It is expected for the rate of

urbanization to increase by 11% and, in combination with a greater loss in natural food sources due to threats like climate change, the number of black bears relying on unnatural food sources are likely to rise (Baruch-Mordo et al, 2014). There needs to be better management strategies put in place in order to make sure our food is out of reach for wildlife, keeping them healthy and preventing them from becoming conditioned to humans and keeping the public safe from potentially dangerous situations.

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